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IRRADIATION OF FABRICS AND LEATHER

by

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FABRICS

A number of fabrics have been subjected to electron bombardment by use of a 2 Mev Van de Graaff electron accelerator, and then evaluated with respect to changes in certain mechanical properties. Acrilan, aminized cotton duck, cotton duck (grey, various samples), cotton sateen, Kuralon, Nylon (Oxford), Nylon (sateen), and various treated fabrics have been irradiated at different dose levels and the effects evaluated.

Table 1 summarizes the results obtained on certain fabrics at dose levels of 2, 100, and 200 megareps as evaluated by determinations of tear strength. The irradiations were in air except in samples D-112 to D-115, where an attempt was made to evaluate the effect of certain additives. Comparison of the results from these four samples with those from the D-1 sample indicates that little or no protection was afforded by the conditions of D-112 to D-115.

Table 2 is a tabulation of the tear strengths obtained for various fabrics at dose levels of 0, 0.5, 1, 2, 5, 10, 20, 40, and 80 megareps. In this series the cotton duck showed the highest rate of deterioration under the five conditions studied, whereas wool-Nylon shirting was the most resistant.

The effect of irradiation on grey cotton duck in air at different dose levels is shown graphically in Figure 1, where tear strength is plotted against dose. It is noted that deterioration appears at very low dose levels and that the rate of deterioration

(Cf. also Figures 2 and 3) decreases with an increase in dose. At 20 megareps, for example, cotton duck has approached maximum deterioration with respect to tear strength.

The deterioration plots for Acrilan, Nylon sateen, Kuralon sateen, Oxford Nylon, cotton sateen, cotton duck (grey), and aminized cotton duck, are given in Figure 2. The highest rate of deterioration is that of Nylon sateen whereas the lowest is for Kuralon sateen.

In Figure 3 the "original strength retained," expressed in per cent, is plotted against the dose in megareps. At 200 megareps, Kuralon retains about 65%, Acrilan and Oxford Nylon about 45%, Nylon sateen about 30%, and grey cotton duck only about 5% of their original tear strength.

From these data it is observed that the tear strength of fabrics generally decreases with an increase in the amount of irradiation, but that the slope of the deterioration curve is a function of the nature of the fiber, the fabric, and its treatment. Deterioration is usually detectable at or below two megareps and the slope of the curve normally decreases with an increase in total dose. Initially the deterioration is relatively rapid. In the case of Nylon (Oxford) the apparent improvement at the high dose level may be attributed to sampling or experimental error. Among the more resistant fabrics studied are Kuralon, Acrilan, and some of the Nylons. In one experiment not included in the data, the irradiation of Nylon in vacuum showed only slight deterioration whereas a comparable sample similarly irradiated in air retained only about 25% of its initial properties as determined by its stress-strain curve.

It is noted that insolubilized polyvinyl alcohol (Kuralon), polyacrylonitrile (Acrilan), and poly(hexamethyleleadipamide) (Nylon), are the most resistant to irradiation, and that Nylon undergoes relatively little deterioration when irradiated in vacuum. It is planned to study further the irradiation technics applicable to these materials with the hope of attaining optimum conditions for each to minimize deterioration and then correlate the chemical structure of the material with the experimental conditions for irradiation.

Kuralon is a polyvinyl alcohol which has been insolubilized by treatment with an aldehyde in the presence of ultraviolet light, thus producing ether linkages which are relatively resistant to oxidative irradiation. It may be presumed that irradiation of Kuralon in vacuum would effect even less deterioration than that observed in this study.

In the case of grey cotton duck, as judged by decrease in tear strength, irradiation appears to cause about the same deterioration as does weathering. The tear strength (248 lbs.) of a 12 oz. cotton duck, for example, was decreased to 65 pounds by weathering for 15 months and to 64 pounds by exposure to 45 megareps.

In one series of experiments on the irradiation of grey cotton duck, the effects were evaluated by both tear strength measurements and weight loss. From the consistency of the pattern obtained in this "spot" experiment it seems likely that weight loss may be a more sensitive measure of the deterioration of cotton duck by irradiation than is a change in tear strength. This experiment was not designed to identify the volatile materials, which cause the loss in weight, but such a study is contemplated.

All doses at 2 megareps and above were given at 2 megareps per pass under the beam, with the conveyer belt moving at about one foot per minute. Where multiple passes are involved, there was about a twenty minute interval between successive passes, hence the heat effect on a sample caused a rise in temperature of not more than about five degrees centigrade.

LEATHER

Chrome-tanned, chrome-retanned, vegetable-tanned upper leather, and untanned hide samples have been exposed to electron bombardment by a Van de Graaff electron accelerator at two megareps per pass at different dose levels, and the effects evaluated by use of bursting strength (1/8 inch plunger, 3/8 inch orifice), stitch-tearing strength, and shrinkage temperature (methods E-13 and E-14 of the American Leather Chemist's Association Methods Book and Federal Specification KKL-311).

Some of the results are shown graphically in Figures 4, 5 and 5a. Significant changes in the shrinkage temperature, bursting strength, and stitch-tearing strength were not observed for the chrome-tanned samples at the two megarep level but they were noticeable for the chrome-retanned and the vegetable-tanned leather. At higher dose levels, the deterioration of physical properties becomes apparent by all three tests.

Figure 5a, on which "degrees less than the control" is plotted against the total dose in megareps, graphically illustrates the effect of irradiation on the shrinkage temperature of both chrome-tanned and chrome-retanned leather. It is observed that above 100 megareps the effect levels off. Vegetable side leather upon irradiation at a comparable dose level becomes so brittle that it breaks in the Theis Shrinkage meter.

Table 3 and Figure 6 are tabular and graphic records of the data obtained in a series in which dehaired, delimed, and dehydrated hide was studied with respect to the effect of irradiation on burst strength, shrinkage temperature, stitch-tearing strength, and soluble nitrogen, in both air and argon atmospheres and under both dry and moist conditions. The argon atmosphere appears to give less deterioration than air although not consistently. This may be attributed in part to the commercial composition of the argon used and particularly to the fact (observed in studies on monomer systems) that at low doses the argon does not serve as an energy carrier. The moist samples, in general, deteriorated less than did the dry samples. The soluble nitrogen determinations[a] gave the highest values for the dry samples, except for the controls, and at the higher dose levels the samples in argon gave about 10% more soluble nitrogen than did the comparable samples packaged in air.

From Table 3 it is observed that an improvement in stitch-tearing strength and in burst strength occurred at low dose levels, but it seems likely that this may not be significant and might be attributed to variation in samples.

In another study the effects of gamma-rays on hide and on chrome leather obtained from irradiated hide were evaluated. Four samples of the same hide were divided, one half was used as a control and the other exposed to irradiation as indicated in Table 4.

Table 4. Gamma-Irradiation of Hide and of Chrome Leather Obtained from Irradiated Hide.

No.	Dose Megareps	Burst Strength lbs./in.[c] Untanned 1954	Untanned 1958	Tanned 1954	Tanned 1958	Shrinkage in Water — 0°C.[a] Untanned 1954	Untanned 1958[b]	Tanned 1954	Tanned 1958[b]
A-0	0	—	—	800	640	64	—	106	94
A-1	2	—	—	780	690	60	—	95	91
B-0	0	—	—	970	690	63	—	106	94
B-1	10	—	—	290	340	51	—	—*	—*
C-0	0	1240	1100	—	—	63	60	—	—
C-1	2	1300	1220	—	—	57	50	—	—
D-0	0	1370	1190	—	—	65	63	—	—
D-1	10	730	770	—	—	42	39	—	—

a. Except for 1954 values for the A and B samples which were obtained in glycerin-water mixture.
b. Mean value of two determinations.
c. Mean value of four determinations.
*Lost ability to contract.

The effect of irradiation of a hide prior to tanning was studied as a possible tanning aid, but the deterioration effects were even more pronounced than in the case of tanned leather. One may postulate that (1) mild irradiation ruptures the cross-links of the protein chains in the "protofibrils" of the hide to an extent that subsequent chrome-tanning (the remarkable hydrothermal-stability effect being ascribed to cross-linkages) does not restore the breaks inasmuch as the capacity of the chrome complex to bridge the distance between the protein chains is very limited, and (2) stronger irradiation affects the cohesion of the fiber bundles, with a consequent loss in mechanical strength.

On the basis of these studies on the irradiation of various types of hide and leather, one may conclude that: (1) damage in hide and leather occurs at relatively low levels of irradiation, (2) the first effect is a lowering of the resistance to wet heat[3] (shrink resistance), (3) larger doses weaken the fiber structure and lead to increased loss in strength, and (4) the results of electron irradiation under the conditions of these experiments are consistent with those obtained by gamma-irradiation as reported by Victor G. Vely of the Battelle Memorial Institute at the A.I.C.A. meeting at Mackinac Island in June of 1959.

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References

1. Poly(vinyl acetate) has been cross-linked by irradiation (Brit. 798,146, 16 July 1958). It is likely that cross-linking accounts in part for the irradiation stability of Kuralon.

2. Kanagy, J. R., J.A.L.C.A. 32, 12 (1937).

3. Cassel, J., J.A.L.C.A. 54, 432 (August 1959).

Table 1. Tear Strengths of Certain Irradiated Fabrics

Exp. No.	Fabric	Tear Strength (Warp) at Dosage Levels of: 0.0	2.0	100.0	200.0 Megareps	Comments
D-1	Cotton, Duck, Grey	4.3	4.0	0.8	0.2	
D-41	Oxford Nylon Cloth	5.8	5.6	2.6	2.2	
D-42	Cloth, Sateen, X-51	4.15	3.7	1.2	0.75	
D-43	Cloth, Acrilan, Sateen	17.4	16.6	10.1	7.8	
D-44	Cloth, Nylon, Sateen	26.3	24.1	10.8	8.6	
D-45	Cloth, Ctn, Sateen, Corded	13.6	11.0	1.1	0.2	
D-46	Cloth, Ctn, Kuralon, Sateen	8.6	7.7	6.2	5.8	
D-47	De Cetex 104	8.0	7.3	1.0	0.3	
D-48	BA 110, SRRL	1.4	1.3	0.25	0.1	
D-49	BA 109, SRRL	1.35	1.3	0.3	0.1	
D-50	BC 910, Aminized Cotton	2.5	2.3	0.6	0.1	
D-112	Cotton, Duck, Grey	4.3	4.0	1.1	0.1	As is, sealed in petri dish.
D-113	Cotton, Duck, Grey	4.45	3.7	0.9	0.25	Dried, sealed in petri dish.
D-114	Cotton, Duck, Grey	4.1	3.75	1.3	0.3	In C_6H_6/C_5H_5N in petri dish.
D-115	Cotton, Duck, Grey	4.1	3.65	0.9	0.45	In toluene/pyridine/ petri dish.

Table 2. Tear Strength of Certain Irradiated Fabrics

Exp.	Fabric	Tear Strength (Warp, lbs.) at Megarep Dosage of:									Remarks
		0.0	0.5	1.0	2.0	5.0	10.0	20.0	40.0	80.0	
D-128-9	Cotton, Duck Grey	4.4	4.2	4.1	3.6	3.5	3.0	2.0	1.8	1.5	In air/petri dish
D-130-1	Cotton, Duck Grey	4.6	4.2	4.1	3.9	3.4	2.5	1.9	1.7	1.2	In N_2/ petri dish
D-137	Cloth, Worsted, Tropical, Khaki	4.1	4.0	3.8	3.7	3.6	3.4	3.3	3.2	3.1	Irradiated on shuttle
D-138	Cloth, Wool-Nylon Shirting	5.3	5.2	5.15	5.0	4.6	4.7	4.4	4.35	4.3	On shuttle belt.
D-139	Cloth, Cotton, W.R.Sateen 93	8.2	10.0	8.1	7.8	7.1	6.0	4.8	4.3	3.3	On shuttle system
D-141	Silk, Bunting	7.4	6.7	6.3	6.2	5.3	5.2	5.1	4.1	3.7	On shuttle system
D-146	Cotton, Duck, Grey	4.4	4.3	4.4	3.9	3.8	3.2	2.8	1.6	1.1	Irradiated wet
D-147	Cotton, Duck, Grey	4.4	4.2	4.1	3.7	3.3	2.8	2.7	2.6	0.8	Irradiated dry
D-148	Cotton, Duck,	4.5	4.4	3.9	3.7	3.2	2.9	2.8	2.5	0.8	Irradiated dry/in N_2

Table 3. Effect of Irradiation on Shrinkage Temperature, Soluble Nitrogen, Stitch Tear and Burst Strength

Sample*	Medium	Shrink. Temp. °C.	% Soluble N_2	Stitch Tear** lb/in	Stitch Tear** %change	Burst Strength*** lb/in	Burst Strength*** %change
A_o	Dry	60.0	0.8	889		1635	
C_o	Moist	61.0	1.0	883		1700	
B_1	Air Dry	46.0	2.4	776	-13	740	-54
D_1	Air Moist	56.5	1.5	1180	+34	1755	+ 3
A_1	Argon Dry	50.0	2.2	844	- 5	1890	+16
C_1	Argon Moist	55.0	1.4	870	- 1	1020	-40
B_2	Air Dry	31.0	11.1	684	-23	715	-56
D_2	Air Moist	36.0	5.8	714	-19	1180	-31
A_2	Argon Dry	31.0	13.7	545	-39	990	-39
C_2	Argon Moist	35.5	4.7	665	-25	680	-60
B_3	Air Dry	31.0	26.5	363	-59	825	-50
D_3	Air Moist	30.0	13.7	412	-53	930	-45
A_3	Argon Dry	30.5	28.7	396	-55	920	-44
C_3	Argon Moist	29.0	11.8	496	-44	1120	-34

*Subscripts indicate total intensity to which samples were exposed

o signifies control
1 " 1 pass of 1 mgr. intensity = 1 mgr. total
2 " 5 " " 2 mgr. " = 10 mgr. total
3 " 10 " " 2 mgr. " = 20 mgr. total.

**2 hole stitch tear test; one measurement per sample
***1/8 inch plunger used; average of a minimum of 3 measurements made within a 1 1/2 inch diameter circle.

FIGURE 1

IRRADIATION of GREY COTTON DUCK in AIR (D-130 & D-131).

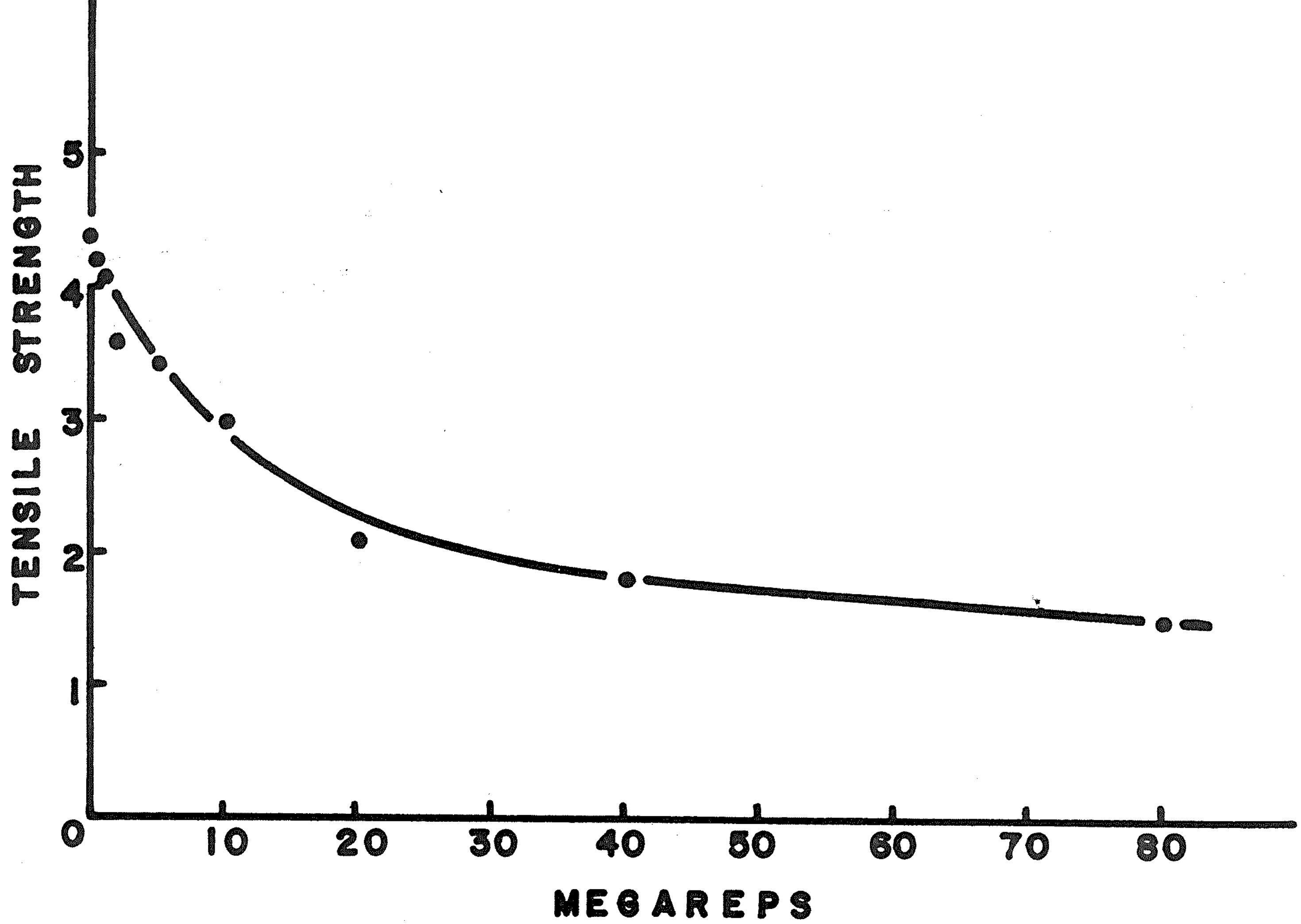
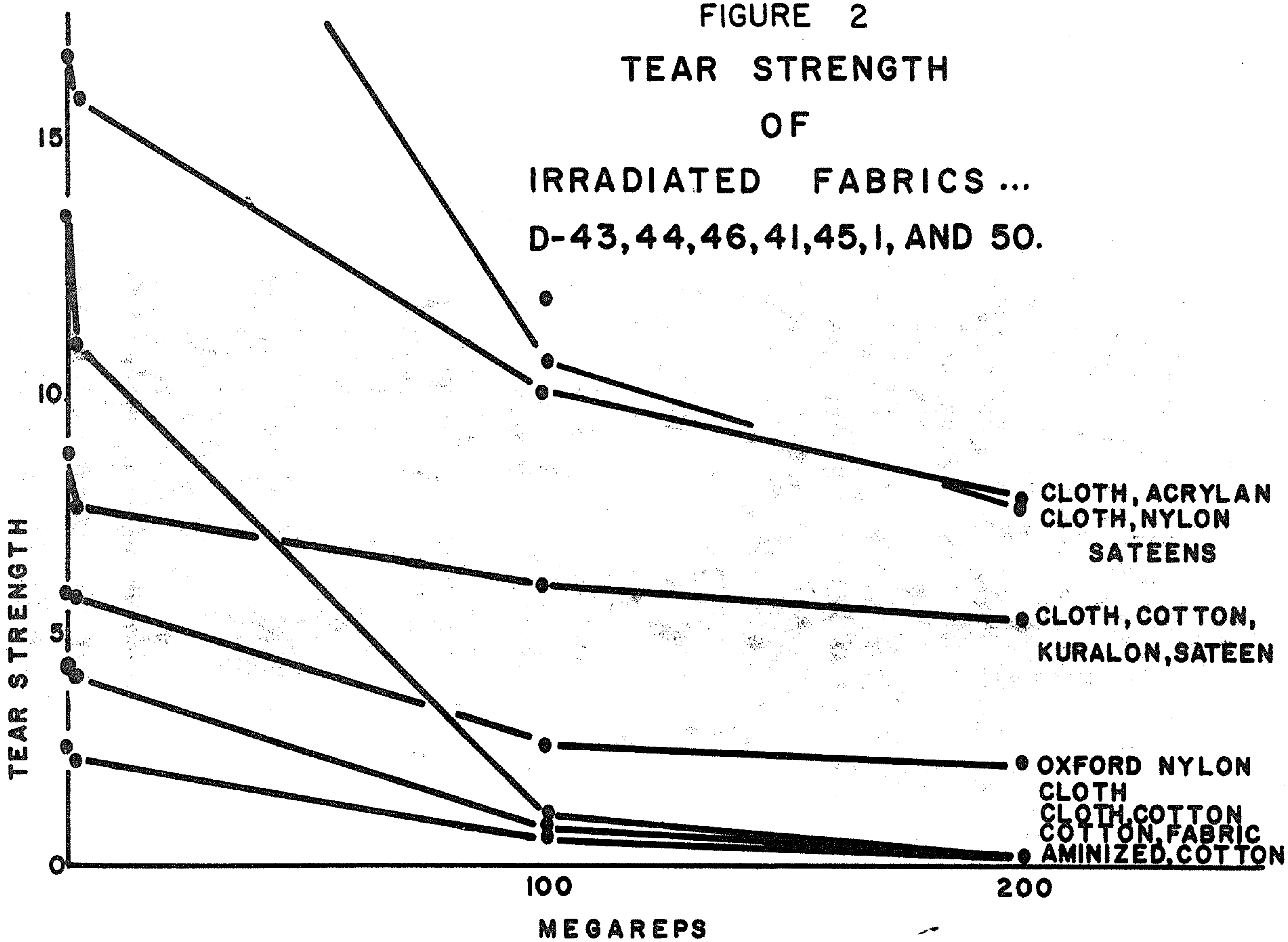


FIGURE 2
TEAR STRENGTH
OF
IRRADIATED FABRICS ...
D-43, 44, 46, 41, 45, 1, AND 50.



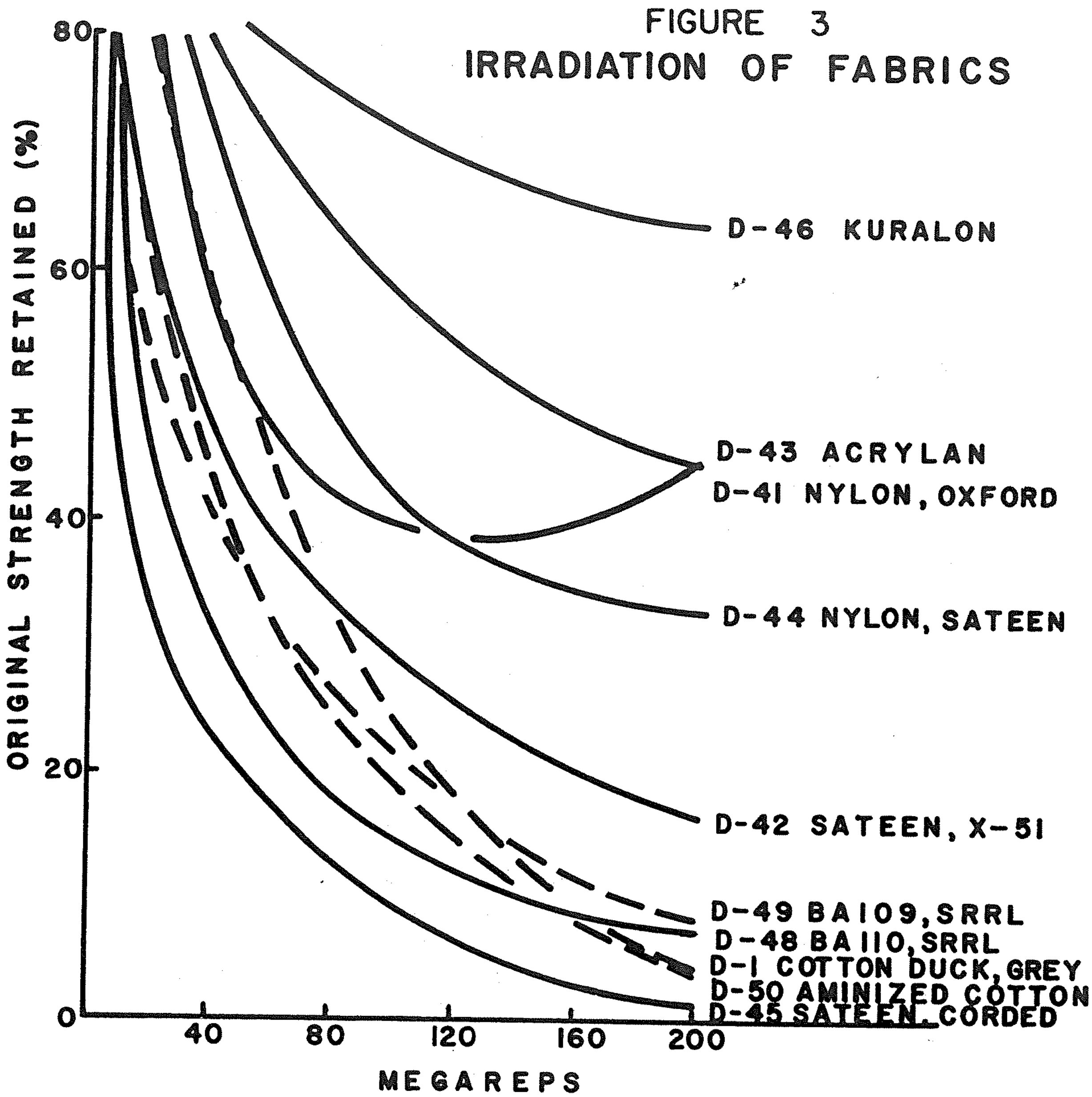


FIGURE 3
IRRADIATION OF FABRICS
D-46 KURALON
D-43 ACRYLAN
D-41 NYLON, OXFORD
D-44 NYLON, SATEEN
D-42 SATEEN, X-51
D-49 BA109, SRRL
D-48 BA110, SRRL
D-1 COTTON DUCK, GREY
D-50 AMINIZED COTTON
D-45 SATEEN, CORDED
ORIGINAL STRENGTH RETAINED (%)
0
20
40
60
80
40
80
120
160
200
MEGAREPS

FIGURE 4

IRRADIATION OF TANNED LEATHER AND COTTON DUCK.

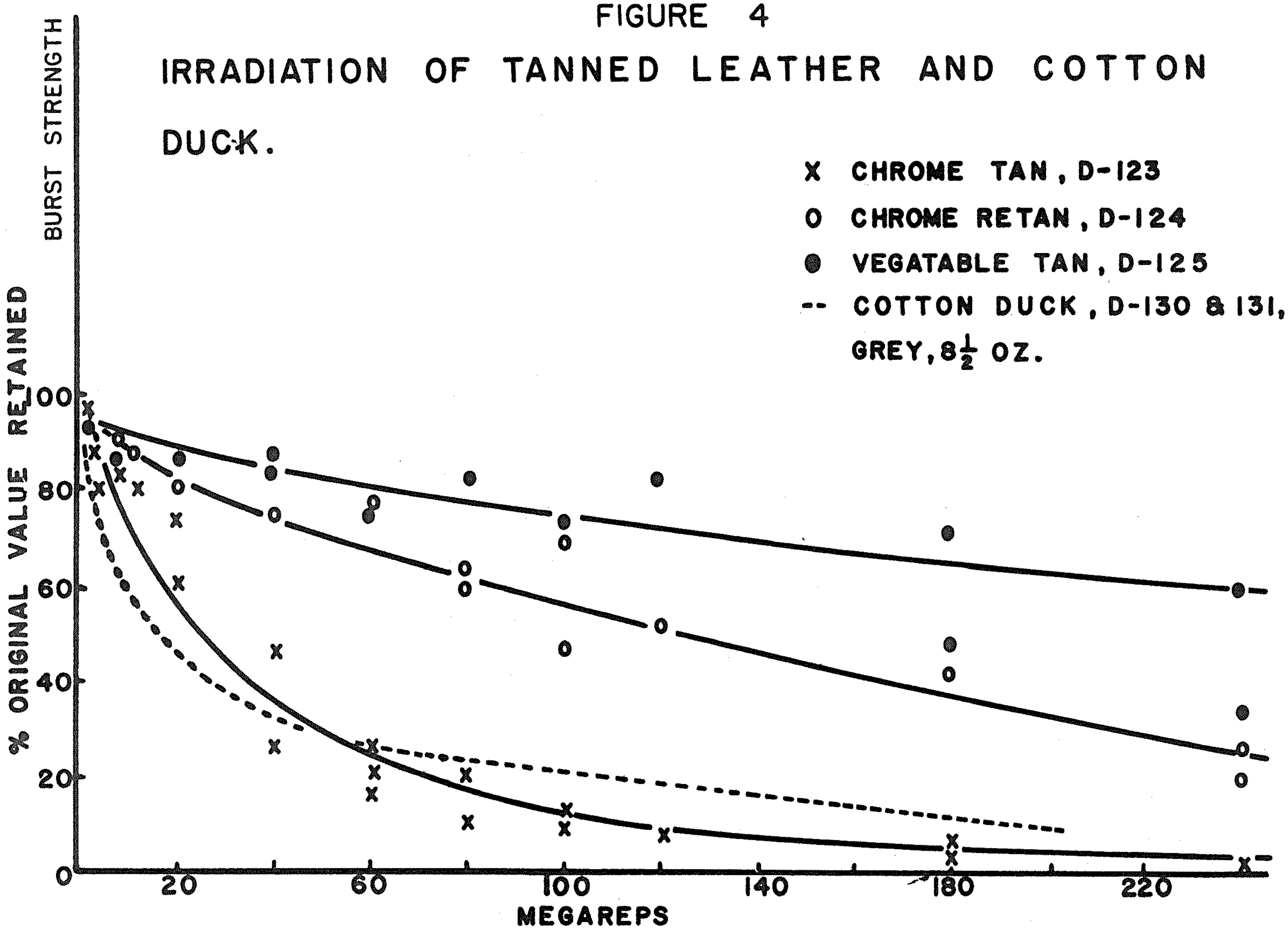


FIGURE 5

SHRINKAGE TEMPERATURES (glycerine 75%)

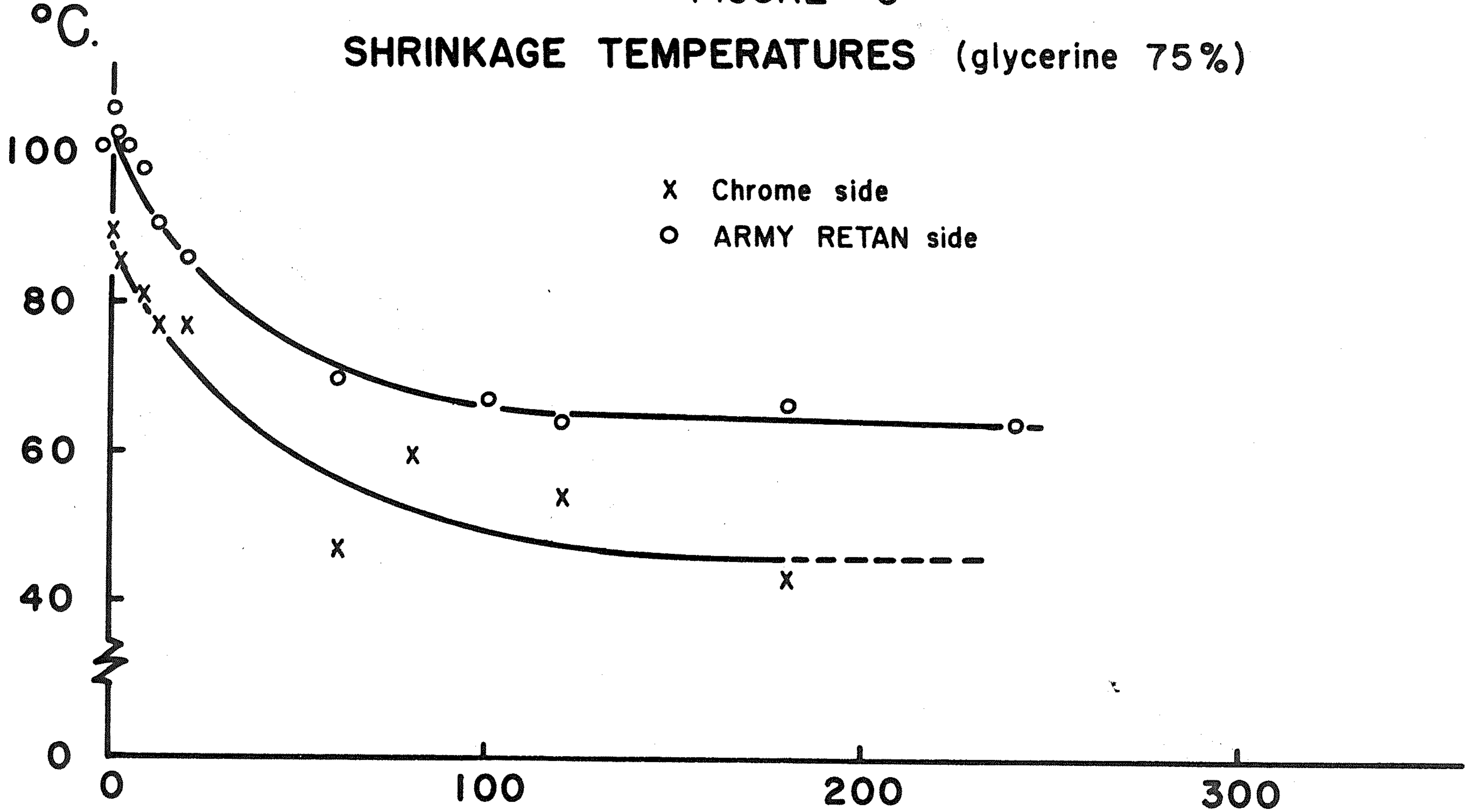


FIGURE 5a

EFFECT OF IRRADIATION ON SHRINKAGE TEMPERATURE, °C.

Loss in Degrees Versus Dose

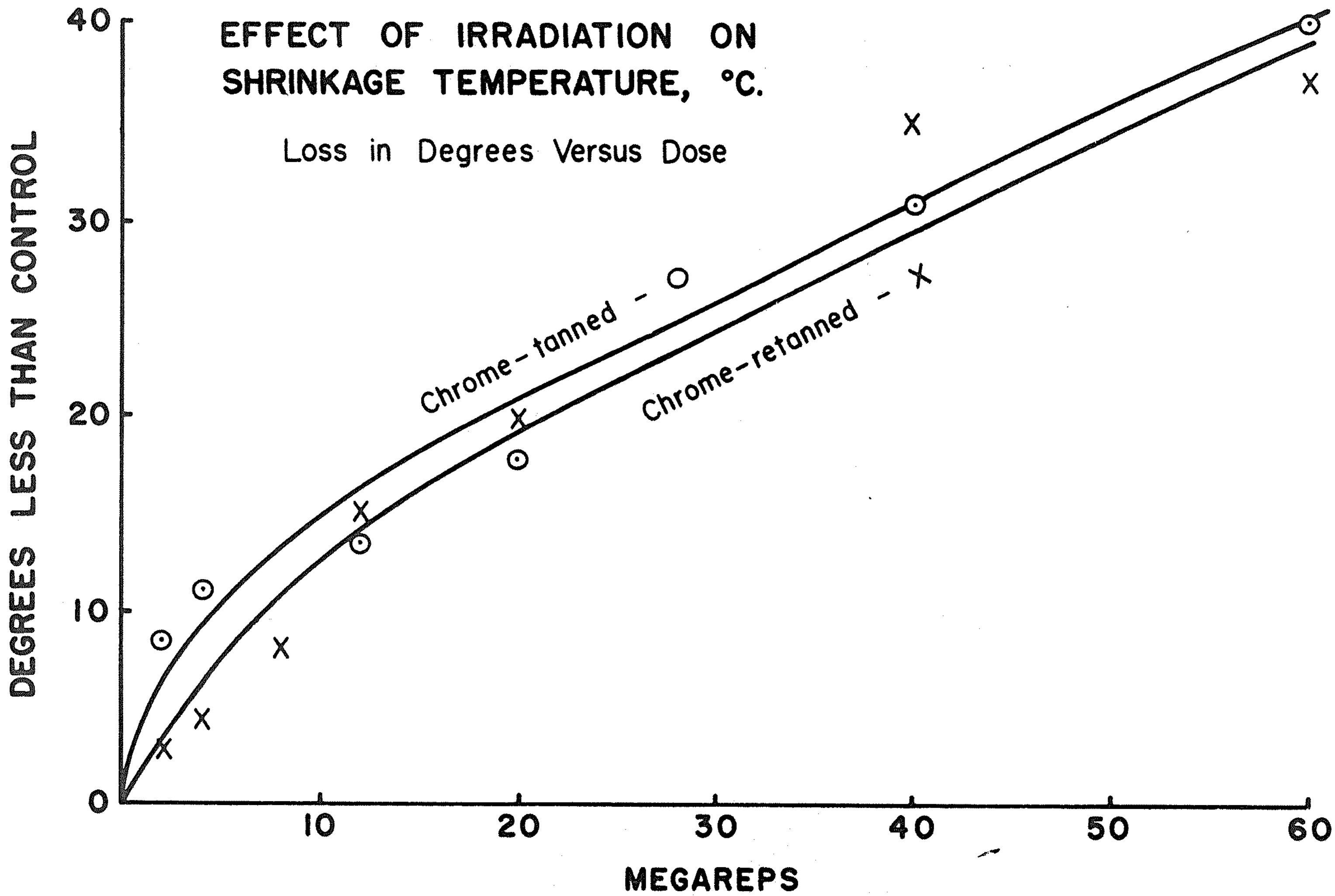


FIGURE 6

EFFECT OF IRRADIATION ON BURST STRENGTH AND STITCH-TEAR STRENGTH